PHYTOTOXICOLOGY 1996 SOIL INVESTIGATION: DOMINION COLOUR CORP. AJAX, ONTARIO

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Report No: SDB-065-3511-96

Abstract
Phytotoxicology 1996 Soil Investigation:
Dominion Colour Corporation - Ajax
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In 1996, an investigation involving the collection of soil samples with subsequent analysis for the metals; Cd, Co, Cr, Cu, Fe, Mn, Mo, Ni, Pb, Sr, and Zn, was conducted in the vicinity of Dominion Colour Corporation, a company that manufactures lead chromate pigments in Ajax, Ontario. Dominion Colour Corporation has increased production of lead chromate pigments in the past 9 years and soil Pb and Cr concentrations immediately around the plant have significantly increased since the last Phytotoxicology investigation in 1987. Soil Cr, Pb, Mo and Sr concentrations were particularly high at Sites 1, 2 and 13, which are all adjacent to the plant and on company property. Soil lead concentrations at Site 13 exceeded the Soil Remediation guidelines for industrial sites, but no exceedances of these guidelines were noted off company property for any of the metals of interest. Contour maps of Cr, Pb, Mo and Sr clearly show soil metal concentration gradients relative to Dominion Colour that decrease to background concentrations within a few hundred metres of the plant.

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1 Introduction

In September 1970, Dominion Colour Corporation erected a plant to produce lead chromate pigments on a 16 acre site in Ajax, Ontario. Four years later, in response to concerns that chromium (Cr), molybdenum (Mo) and especially lead (Pb) emissions from the plant might be in excess of their respective impingement standards, staff of the Phytotoxicology Section of the Ontario Ministry of the Environment and Energy (MOEE) conducted soil and vegetation investigations in the vicinity of this plant. This first investigation in 1974 found that soil concentrations of Cr and Pb were not elevated, however vegetation concentrations of Cr and Pb were elevated above background concentrations at sites close to the plant (MOE, 1975). These findings established the need for follow-up investigations, which were carried out in 1975 and 1976. These subsequent investigations found no indication of excessive concentrations of either Cr or Pb in either soil or vegetation (MOE, 1976, MOE, 1977). The next investigation was conducted 13 years later in 1987. In this investigation, soil samples were collected from many of the sites sampled in 1974 as well as several new sites. In addition, a moss bag investigation was conducted in 1987 and 1988. The results of the soil sampling indicated that soil concentrations of Cr, Pb and Mo close to the plant were elevated relative to background concentrations. At some sites, soil concentrations of Cr and Pb were 10 times greater than in the 1976 investigation. The results of the moss bag investigation indicated that Cr, Pb and nickel (Ni) concentrations in the immediate vicinity of the Dominion Colour plant exceeded urban guidelines, implicating the plant as an emitter of these metals. In light of these findings and the ongoing emissions of lead chromate pigments at the Dominion Colour plant, staff at the MOEE York-Durham District Office requested that an investigation around Dominion Colour be conducted by staff of the Phytotoxicology Section in 1996 to determine if concentrations of Pb and Cr had continued to increase in soil in the vicinity of the plant.

2 Methods

On July 11, 1996, soil samples (0-5 cm) were collected from 11 sampling sites in the vicinity of the Dominion Colour plant (Figure 1). Nine of these sites (Sites 1,2,3,4,5,7,8,13 and 16) were the same sampling sites that had been used in the 1987 soil collections. Two new sites (Sites 17 and 18) were added as remote or control sites. Duplicate soil samples were collected at each site with an Oakfield™ soil sampler, using standard sampling procedures.

Soil samples were sent to the MOEE Laboratory Services Branch for chemical analysis. The soil was air dried, thoroughly mixed and sieved first through a 2 mm sieve and subsequently through a 0.355 mm sieve. Soil metal concentrations were determined by inductively coupled plasma - optical emission spectrometry (ICP) after digestion of the sample with concentrated nitric and hydrochloric acid in a hot block digester. Detailed analytical methods used are given in Ontario Ministry of the Environment Handbook of Analytical Methods (1983).

3 Results and Discussion

Dominion Colour Corporation's plant in Ajax, Ontario has become one of the world's leading producers of lead chromate pigments. Capacity at the Ajax site has increased more than 60% since the early 1990s with the potential for greater emissions of Pb and Cr. Emissions of Mo, Sr and Zn are also likely since this plant has been a producer of molybdate orange pigment, as well as zinc and strontium chromate anti-corrosive pigments. The results of the current investigation indicate that soil concentrations of Co, Cr, Mo, Pb and Sr exceed the OTR98 guidelines at several or all of the sites adjacent to the Dominion Colour plant (Table 1). The OTR98 guidelines represents the high end of the soil chemical concentration range in soils collected from old urban parks throughout Ontario. Exceeding these guidelines normally indicates the presence of a source of contamination. In addition to the OTR98 guidelines, the values for the effects-based Ontario Soil Remediation guidelines (MOEE,1996) are included in Table 1. Exceeding these Soil Remediation guidelines indicates a potential for adverse effects. Although in most cases the soil metal concentrations were well below their respective Soil Remediation guidelines, the Pb value at one site (Site 13) exceeded these guidelines (Table 1).

The contour maps shown in Figures 2 to 5 give statistical approximations of the spatial distribution of soil Cr, Sr, Pb and Mo concentrations. In all maps, there was a clear metal concentration gradient relative to the Dominion Colour plant. Generally, the contour lines on these maps were set to correspond to a reference value, such as the OTR98 or the Ontario Soil Remediation guidelines. In the Cr contour map (Figure 2), the lowest contour was set at 60 μg/g which is approximately the OTR98 value. This map shows that Cr is elevated above background concentrations within about 200 metres of the Dominion Colour plant. Similarly, in the Sr contour map (Figure 3) the first contour was set at 80 μg/g, which is approximately the OTR98. Although the pattern of Sr contamination around the Dominion Colour plant was similar to that of Cr, the area of Sr contamination is greater, which reflects the above background Sr concentrations at two sites off company property (Sites 8 and 17, Table 1). In the Pb contour map (Figure 4) the first contour was set at 200 μg/g Pb, which is the Soil Remediation guideline for residential properties (MOEE, 1996). This suggests that Pb concentrations are not only above background concentrations but that there has been Pb contamination of the land above the residential soil guideline within approximately 200 m the Dominion Colour plant. The range of soil Mo concentrations (Figure 5) was too large to set the first contour at the OTR98 and the highest value was below the Soil Remediation guideline. Nevertheless, the Mo concentrations also drop off very quickly within a few hundred metres of Dominion Colour. It should be noted that these contour maps can not be used to determine the actual concentration of a contaminant at a location where the sample was not taken.

At sites less than 100 m from Dominion Colour, the concentrations of Cr, Cu, Mo and Pb in surface soil samples have greatly increased since the first investigation in 1974 (Table 2). The largest increase (14 times) has been in the Pb concentration close to the plant (Site 1). Similarly, Cr concentrations have increased up to 3 times at Sites 1 and 2 since the 1974 investigation and 3 times at Site 13 since the 1987 investigation. Mo soil concentrations were not determined in the investigations conducted in the 1970s and so a comparison with samples taken at that time are not possible. Nevertheless, comparing the Mo values from the 1996 investigation with the values in the

1987 investigation indicates that there were large increases at Sites 1(3 times) and 13 (4 times). At all other sites there was no indication of increasing Mo concentrations.

Soil concentrations of Cr, Mo, Pb and Sr were higher at Site 13 than at any other site. The reason for the increased contamination at this Site is unknown. However, in 1993, there was a small organic pigment spill caused by the improper installation of a filter in the organic blender vent system. This dust, reported to be nonhazardous, was blown by a WSW wind over the area to the east of the plant, in the general direction of Site 13.

In addition to the elements discussed above, the ICP analysis provided soil concentrations for the following elements; Aluminum (Al), Barium (Ba), Beryllium (Be), Calcium (Ca), Iron (Fe), Magnesium (Mg), Manganese (Mn), and Vanadium (V). The average soil concentrations for these elements were; Al=12,690 μg/g, Ba =82 μg/g, Be=0.55 μg/g, Ca= 45,172 μg/g, Fe =16,409 μg/g, Mg= 5123 μg/g, Mn= 406 μg/g and V=34 μg/g. Dominion Colour was not considered an emission source of any of these elements and all soil concentrations of these elements, except Ca, were well within background concentrations at all sites. Ca concentrations at Sites 2, 3, 8 and 13 were 70,00 to 80,00 μg/g, which are above the OTR98 of 58,000 μg/g. Why these sites have such high Ca concentrations is unknown, however, because Ca is an essential macronutrient these exceedences are not of concern with regard to phytotoxicity or human health.

In long term investigations, it is often difficult to sample from the same sites. New buildings may be built on the sites or new soil may be brought in that makes historic comparisons impossible. This was true of Sites 5 and 7. At Site 5, a new building was constructed very close to the original sampling site and the soil was probably replaced. This may account for the drop in soil Cr and Pb concentrations at Site 5 in the 1996 investigation compared to previous investigations. Similarly, a building was erected on the original Site 7 location and as a consequence the site was relocated from the west side of the railway tracks to the east side of the railway tracks in the 1987 investigation. Although the site number was retained, this was a new site in the 1987 investigation and therefore, only the data from 1987 and 1996 were included in Table 2 for Site 7.

Soil metal concentrations are considered elevated if they exceed the OTR98 value for urban parkland. This is the most up to date and statistically defensible background reference data available in Ontario. In the 1987 investigation report, soil metal concentrations were compared to "upper limits of normal" (ULN) guidelines, which were based on soil samples collected from either rural or urban areas not subject to the influence of point source emissions. These guidelines were developed after 1983 and were the arithmetic mean plus three standard deviations of analytical data available at the time. In the 1970s investigation reports, soil metal levels were compared to levels that were considered excessive for an urban area. These guidelines were subjective and based on available results of chemical analysis and toxicological information. As the amount and quality of background data as well as the sophistication of the statistical procedures used to analyse the data has increased, the reference values have changed. For example, in the 1970s, the reference level for Pb (levels of Pb considered excessive for an urban area) was 600 μg/g. Whereas in the 1987 investigation the reference level (ULN) was 500 μg/g, and in the 1996 investigation the reference level (OTR98) was 98 μg/g. Lead is a specific concern, because the medical community has revised

downwards the environmental Pb levels considered safe as more is learned about the potential health effects of low levels of Pb exposure, particularly for children. Therefore, the conclusions drawn in past reports must be treated with caution, since they may not be applicable compared to present reference points.

4 Conclusions

Dominion Colour Corporation has increased production of lead chromate pigments in the past 9 years and soil Pb and Cr concentrations immediately around the plant have significantly increased since the last Phytotoxicology investigation in 1987. Soil Cr, Pb, Mo and Sr concentrations were particularly high at Sites 1, 2 and 13, which are all adjacent to the plant and on company property. Soil lead concentrations at Site 13 exceeded the Soil Remediation guidelines for industrial sites, but no exceedances of these guidelines were noted off company property for any of the metals of interest. Contour maps of Cr, Pb, Mo and Sr clearly show soil metal concentration gradients relative to Dominion Colour that decrease to background concentrations within a few hundred metres of the plant.

5 References

MOE, 1975. Investigation final report - Dominion Colour Corporation.

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MOE, 1991. Phytotoxicology assessment surveys in the vicinity of Dominion Colour Corp. Ltd., Finley Ave., Ajax -October 1987 through July 1988. Queen's Printer for Ontario.

MOEE. 1993. "Ontario Typical Range" of chemical parameters in soil, vegetation, moss bags and snow. Phytotoxicology Section, Standards Development Branch. Version 1a, April 1994. PIBS 2792. Queen's Printer for Ontario.

MOEE. 1996. Guideline for use at contaminated sites in Ontario. June 1996. PIBS 3161EO1, Queen's Printer for Ontario.

Table 1: Metal concentrations in soil collected in the vicinity of Dominion Colour Corporation, Ajax - 1996

Site Number	Average Soil Concentration (µg/g, dry weight)										
	Cd	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Sr	Zn
Adjacent Sites											
1 (40 m S)	.55 T	5.2	158	14.5	14500	485	12.6	13.5	705	54	81
2 (100 m SSE)	.35 T	5.6	125	13.5	14500	410	4.3	13.5	360	125	73
3 (40 m N)	.35 T	6.1	44	14.0	16000	365	5.0	15.0	150	105	61
5 (80 m W)	.40 T	6.6	24	18.0	17000	400	1.7 T	14.0	32	65	66
13 (40 m E)	.40 T	6.1	185	15.5	15500	370	33.0	15.5	1200	130	130
16 (100 m SW)	.55 T	6.5	26	22.0	17500	405	1.3 T	16.5	34	66	71
Remote Sites											
4 (200 m N)	.50 T	8.0	27	14.5	20000	445	.5 W	16.5	22	24	64
7 (230 m WNW)	.50 T	7.2	25	17.0	18500	365	.6 T	18.0	25	40	67
8 (180 m E)	.35 T	5.0	19	12.5	14000	340	.8 T	11.5	28	105	54
17 (430 m E)	.35 T	6.4	20	14.0	16500	425	.5 W	14.5	18	80	53
18 (1500 m S)	1.3	6.7	46	32.0	16500	455	.8 T	21.5	39	50	72
OTR98†	.84	17	62	65	33000	1300	.9	32	98	78	140
Clean-up Guideline*	12	100	1000	300			40	200	1000		800

† 98th percentile of the Ontario Typical Range (see Appendix A).

* Ontario Ministry of the Environment and Energy soil quality guideline for commercial/industrial sites

values in shaded cells exceed the applicable OTR98 value.

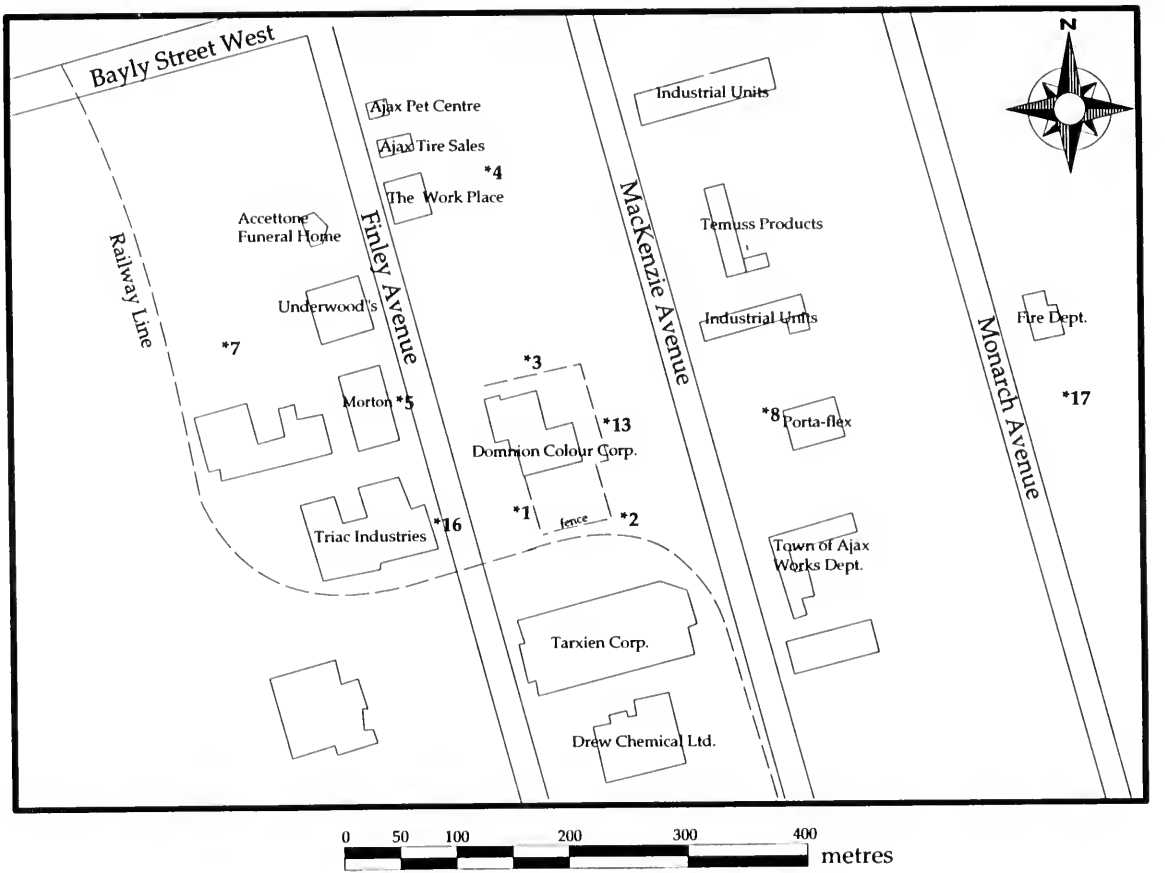
W - at or below analytical detection limits; T - trace amount, interpret with caution

Table 2: Comparison of soil Cr and Pb concentrations detected in the vicinity of Dominion Colour Corp. Ajax, in 1974,1975,1976,1987 and 1996

Collection Site Number	Average Concentration in 0-5 cm Surface Soil (μg/g, dry weight)*											
	Cr					Pb					Mo	
	1974	1975	1976	1987	1996	1974	1975	1976	1987	1996	1987	1996
1 (40 m S)	50	38	10	57	158	50	64	35	170	705	4	12.6
2 (100 m SSE)	45	38	55	140	125	50	77	43	430	360	7	4.3
3 (40 m N)	35	26	23	42	44	33	86	61	86	150	3	5.0
4 (200 m N)	30	26	23	25	27	43	34	27	34	22	<1	0.5 W
5 (80 m N)	45	38	30	36	24	63	71	65	60	32	2	1.7 T
7 (230 m WNW)				24	25				35	25	<1	0.6 T
8 (180 m E)	35	32	23	23	19	65	35	37	22	28	<1	0.8 T
13 (40 m E)				50	185				305	**1200**	8	33.0
16 (100 m SW)				31	26				46	34	<1	1.3 T
Clean-up Guideline†	1000					1000					40	

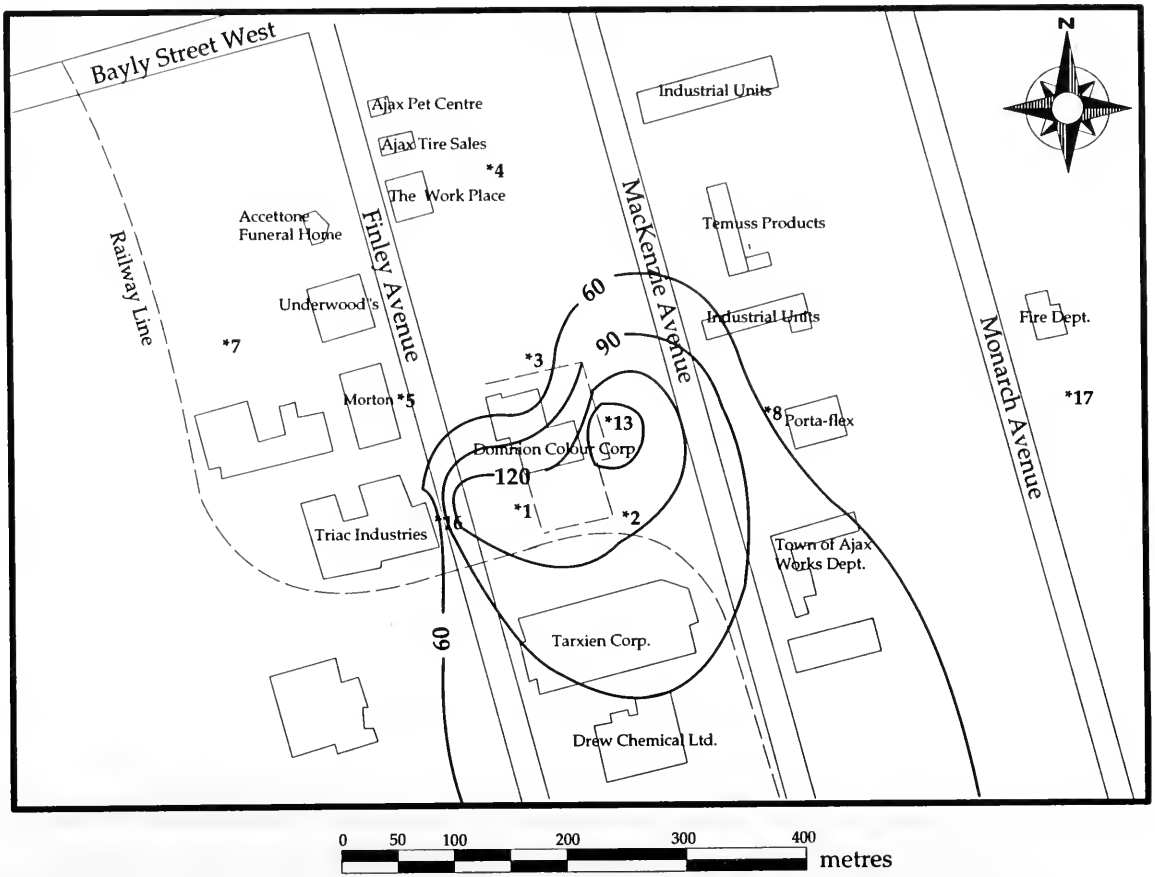
* average of triplicate results in 1974, 1975 and 1976 and of duplicate results in 1987 and 1996.
† 1996 Ontario Ministry of the Environment and Energy soil quality criteria for fine textured soil on commercial/industrial sites
W - at or below analytical detection limits; T - trace amount, interpret with caution

Figure 1: Soil Collection Sites in the Vicinity of Dominion Colour Corp. Ajax - July 1996



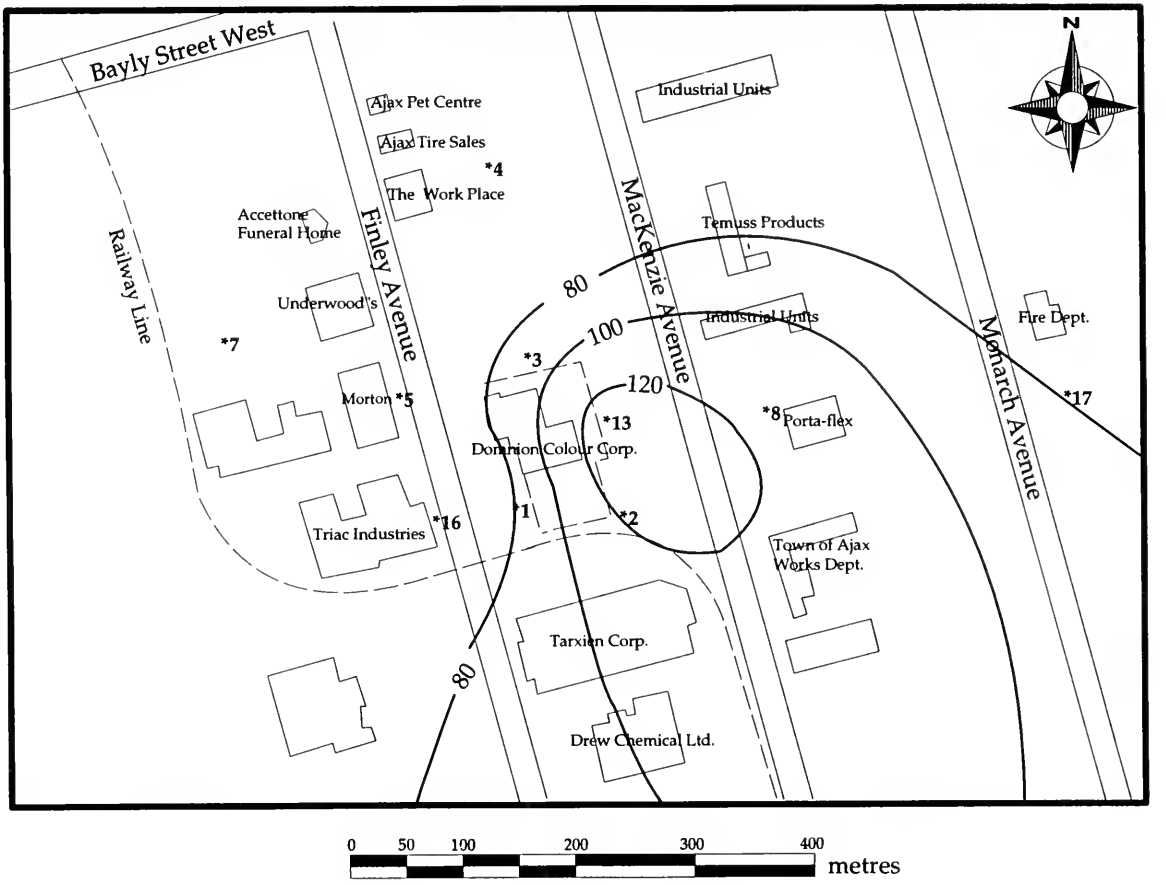
N.B.-- Site 18 is located 1.5 km south of Dominion Colour Corp.

Figure 2: Concentration Contour Map of Chromium in Soil Collectecd in the Vicinity of Dominion Colour Corp. Ajax - July 1996



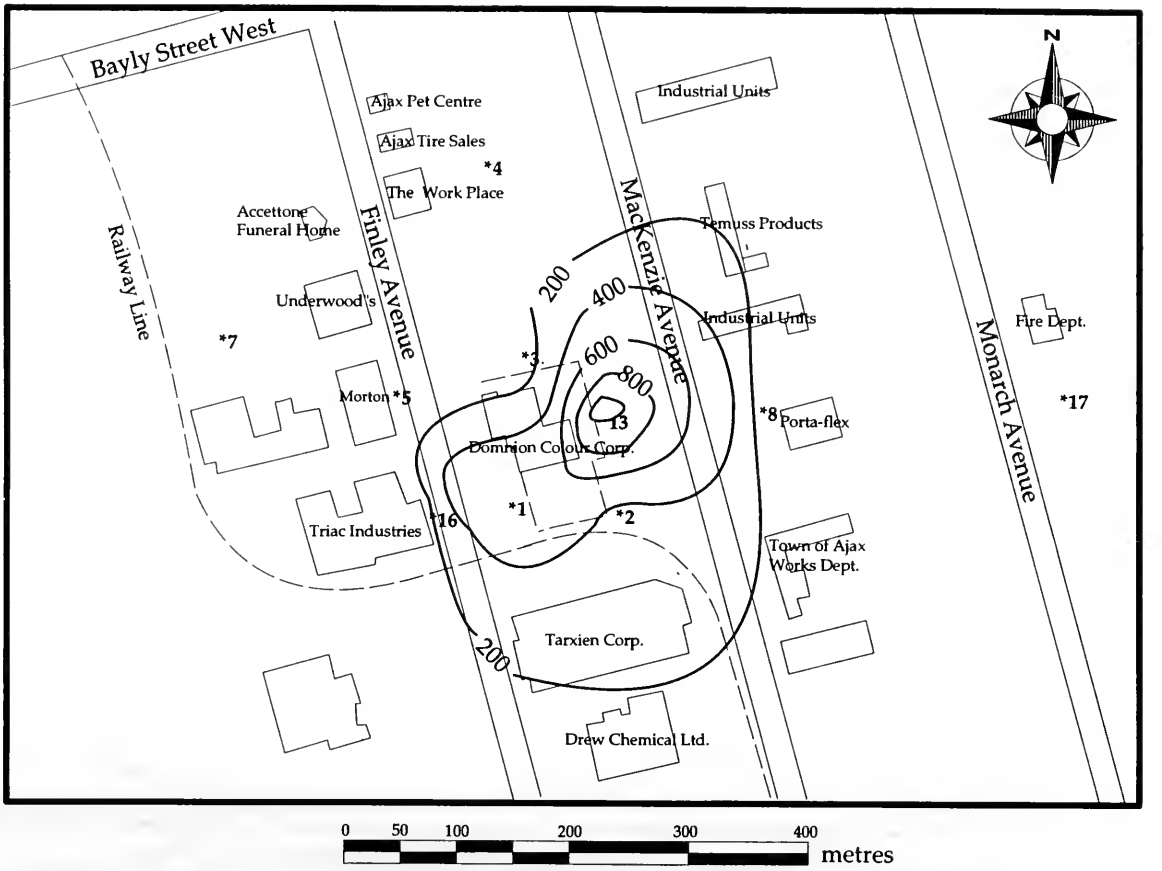
N.B. - Contour line Cr concentrations in ug/g

Figure 3: Concentration Contour Map of Strontium in Soil Collected in the Vicinity of Dominion Colour Corp. Ajax - July 1996



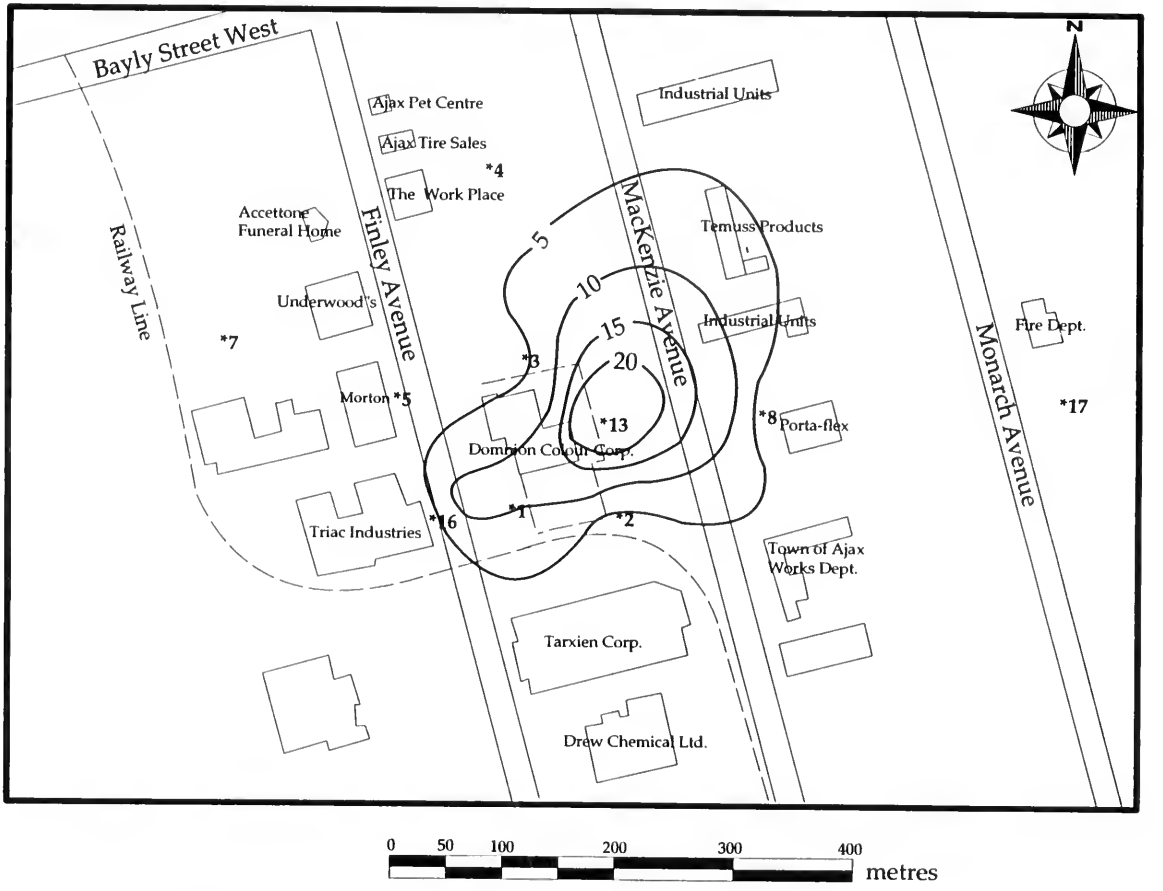
N.B. - Contour line Sr concentrations in ug/g

Figure 4: Concentration Contour Map of Lead in Soil Collectecd in the Vicinity of Dominion Colour Corp. Ajax - July 1996



N.B. - Contour line Pb concentrations in ug/g

Figure 5: Concentration Contour Map of Molybdenum in Soil Collectecd in the Vicinity of Dominion Colour Corp. Ajax - July 1996



N.B. - Contour line Mo concentrations in ug/g

Appendix A:

Derivation and Significance of Ontario Ministry of Environment and Energy (OMOEE) "Ontario Typical Range" of Chemical Parameters in Soil, Vegetation, Moss bags and Snow

The MOEE "Ontario Typical Range" (OTR) guidelines are being developed to assist in interpreting analytical data and evaluating source-related impacts on the terrestrial environment. The OTRs are used to determine if the level of a chemical parameter in soil, plants, moss bags, or snow is significantly greater than the normal background range. An exceedence of the OTR_{98} (the OTR_{98} is the actual guideline number) may indicate the presence of a potential point source of contamination.

The OTR_{98} represents the expected range of concentrations of chemical parameters in surface soil, plants, moss bags, and snow from areas in Ontario not subjected to the influence of known point sources of pollution. The OTR_{98} represents 97.5 percent of the data in the OTR distribution. This is equivalent to the mean plus two standard deviations, which is similar to the previous MOEE "Upper Limit of Normal" (ULN) guidelines. In other words, 98 out of every 100 background samples should be lower than the OTR_{98}.

The OTR_{98} may vary between land use categories even in the absence of a point source of pollution because of natural variation and the amount and type of human activity, both past and present. Therefore, OTRs are being developed for several land use categories. The three main land use categories are Rural, New Urban, and Old Urban. Urban is defined as an area that has municipal water and sewage services. Old Urban is any area that has been developed as an urban area for more than 40 years. Rural is all other areas. These major land use categories are further broken into three subcategories; Parkland (which includes greenbelts and woodlands), Residential, and Industrial (which includes heavy industry, commercial properties such as malls, and transportation rights-of-way). Rural also includes an Agricultural category.

The OTR guidelines apply only to samples collected using standard MOEE sampling, sample preparation, and analytical protocols. Because the background data were collected in Ontario, the OTRs represent Ontario environmental conditions.

The OTRs are not the only means by which results are interpreted. Data interpretation should involve reviewing results from control samples, examining all the survey data for evidence of a pattern of contamination relative to the suspected source, and where available, comparison with effects-based guidelines. The OTRs are particularly useful where there is uncertainty regarding local background concentrations and/or insufficient samples were collected to determine a contamination gradient. OTRs are also used to determine where in the anticipated range a result falls. This can identify a potential concern even when a result falls within the guideline. For example, if all of the results from a survey are close to the OTR98 this could indicate that the local environment has been contaminated above the anticipated average, and therefore the pollution source should be more closely monitored.

The OTRs identify a range of chemical parameters resulting from natural variation and normal human activity. As a result, it must be stressed that values falling within a specific OTR_{98} should not be considered as acceptable or desirable levels; nor does the OTR_{98} imply toxicity to plants, animals or humans. Rather, the OTR_{98} is a level which, if exceeded, prompts further investigation on a case by case basis to determine the significance, if any, of the above normal concentration. Incidental, isolated or spurious exceedences of an OTR_{98} do not necessarily indicate a need for regulatory or abatement activity. However, repeated and/or extensive exceedences of an OTR_{98} that appears to be related to a potential pollution source does indicate the need for a thorough evaluation of the regulatory or abatement program.

The OTR_{98} supersedes the Phytotoxicology ULN guideline. The OTR program is on-going. The number of OTRs will be continuously updated as sampling is completed for the various land use categories and sample types.